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Geologic Hazards and Land-Use Planning, Wasatch Front

see page 3

TABLE OF CONTENTS

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FROM THE DIRECTOR'S DESK

Lessons Learned From the Events of 1983-86

IT almost seems bad luck to suggest that Utah's recent wet cycle is over. But this year's drier-than-average weather has my bones telling me that the worst is over. No definitive scientific evidence supports this hunch but the precipitation cycle of 1982-86 closely resembles the wet cycle that began in 1866 and ended 1870. In addition, the pumping project to the West Desert and the weather have drawn the lake down to such an extent that the sense of imminent danger also has evaporated.

Although we may not be out of the wet cycle, now is a good time to document the lessons learned by the UGMS and the earth-science community so that we can be better prepared for the next wet period; be it in the next couple of years or next few decades.

In a future Director's Corner, I will share some of what we've learned about the geologic phenomena associated with the wet cycle (debris flows, high ground water, landslides, rising lakes, sedimentation, flooding, and avalanches). In this Director's Corner, I want to share some of the policy-related lessons I've learned.

Lesson #1: What's "normal"?

I think the most important lesson I've learned from this wet cycle is that wet cycles and associated phenomena are "normal"...and it's we, the residents of the state, who may react to the wet cycle a bit strangely, not the hillsides, lakes, and ground water. Although precipitation was considerably above average for the region, past lake levels, meteorological records, and debris flow sediments indicate that such events are normal. It doesn't take a greenhouse effect, volcanic debris screening sunlight, or a reentry into the Ice Age to cause the Great Salt Lake to rise even above its present level to 4217 feet above sea level. Occasional debris flows happen along the Wasatch Front and central Utah nearly every year and short-term climatic conditions have resulted in multiple debris flows every 30-40 years. These phenomena are a part of our environment and can be expected to occur again in the lifetimes of our communities.

Lesson #2: What is a wet cycle?

It's not easy to recognize when we're in...or out...of a wet cycle. However, in retrospect, we are far more aware of the precursors of wet cycle phenomena today than in 1982. We understand far better the processes of debris flows, the usefulness of monitoring systems, and the role of geologists in responding to emergencies. If the snowpack of 1983 were to occur in 1987, the UGMS could anticipate conditions and provide more effective advice to protect lives and property than our capability permitted in 1983.

Lesson #3: Lives versus property

Most geologic hazards damage property, some also endanger lives. Debris flows, for instance, can be killer phenomena, whereas the rise of the Great Salt Lake which causes extensive damage to property need not pose risks to lives. It is important to remember this distinction when preparing for, controlling, or responding to wet cycle hazards. Our attempts to protect property should not convert conditions into life-threatening hazards. For instance, West Desert pumping lowers the lake along the populous Wasatch Front without

Continued on page 14

GEOLOGIC HAZARDS AND LAND-USE PLANNING, WASATCH FRONT

Gary E. Christenson, UGMS
Mike V. Lowe, Weber-Davis County Geologist
Craig V. Nelson, Salt Lake County Geologist
Robert M. Robison, Utah-Juab County Geologist

GEOLOGIC HAZARDS ORDINANCES AND THE COUNTY HAZARDS GEOLOGIST PROGRAM

INTRODUCTION

Geologic hazards play a significant role in life along the Wasatch Front and have caused hundreds of millions of dollars in property damage and one fatality during the last 5 years. The Wasatch Front is particularly vulnerable because of the variety of hazards and concentration of population in the area. Although a great number of techniques are available to mitigate geologic hazards, one of the most effective and least costly is proper long-range land-use planning based on a thorough knowledge of the hazards and their potential impacts. However, planning with respect to geologic hazards along the Wasatch Front has been difficult because of a lack of hazards information, particularly in the form of understandable (translated) hazards maps at suitable scales. These maps and information are rapidly becoming available, and the need now is to devise a means to aid planners in incorporating this information into the planning process.

The principal hazards affecting Utah and the Wasatch Front include earthquakes and related effects, landslides, debris flows, rock falls, flooding, problem soils, and a variety of other, less common, phenomena. A brief survey of the types of hazards and efforts of the Utah Geological and Mineral Survey (UGMS) to compile information on these hazards is included in the Spring 1986 issue (v. 20, no. 1) of Survey Notes entitled "Utah's Geologic Hazards." The 1986 article does not discuss the use of this information in planning, and it is the purpose of this issue to discuss how that is presently done and to summarize efforts to facilitate implementation through the UGMS-sponsored County Hazards Geologist Program.

LOCAL GOVERNMENT ORDINANCES

Most land-use planning is done at the city and county level through master plans, zoning and subdivision ordinances, and/or site development codes. Master plans and zoning ordinances define areas where hazards may exist, generally termed Hillside Protection Zones, Sensitive Areas, or Critical Environmental Zones, and place restrictions or conditions on development. Subdivision ordinances and site development codes apply to all areas where the applicable land uses are planned, but do not specifically delineate hazard zones. In hazard areas as defined in a master plan or zoning ordinance, local jurisdictions require site-specific engineering geologic reports to address hazards prior to development. In subdivision ordinances and site development codes, reports may be required at the discretion of the planning commission. Because these commissions and their staffs commonly lack geologic expertise to determine where reports are needed, subdivision ordinances and development codes are most effective if hazards maps are included in the ordinance. Few jurisdictions have done this along the Wasatch Front, in part because few such maps have been available.

Ordinances which require site-specific engineering geologic reports in hazard areas to address hazards and recommend mitigation measures can be very effective and yet not overly restrictive, allowing land uses to be evaluated on a case-by-case basis from the best available information.However, methods used in implementing this approach along the Wasatch Front have not been completely effective. Because of a lack of hazards maps at appropriate scales translated into terms understandable to planners, reports are commonly not required where needed. Also, the qualifications of those preparing reports are not outlined in specific detail so that reports are commonly not prepared by qualified engineering geologists but by engineers or by unqualified geologists lacking the necessary experience and expertise. Finally, no allowance is made for review of reports by qualified geologists acting on behalf of local government. A survey of local government officials in 1986 found that most did not perceive the need for review because they saw no problems with reports submitted. Many, however, admitted that they were not in a position to judge, and the same survey showed that government geologists perceived a major problem. A more detailed review of geologic hazards ordinances in Utah and other states along with recommendations regarding content of ordinances is included in UGMS Circular 79 (Christenson, 1987), "Suggested Approach to Geologic Hazards Ordinances in Utah," available free of charge from the UGMS.

Because of the deficiencies in Wasatch Front ordinances and the general lack of necessary hazards information and maps on which to base planning decisions, land use has progressed in many areas without proper consideration of hazards and the risks they present to structures and people. Some of the damage incurred in recent wet years could have been avoided through proper land use with respect to the rise of Great Salt Lake, stream flooding, debris flows, and landslides. Although damages were extensive, those that may result from a large earthquake along the Wasatch Front are potentially much greater, and can be reduced by wise land-use practices.

COUNTY HAZARDS GEOLOGIST PROGRAM

The disastrous hazard events during the spring of 1983 caused an increased awareness of geologic hazards and prompted then-governor Matheson to convene the "Governor's Conference on Geologic Hazards" (Utah Geological and Mineral Survey, 1983). Extensive flooding and debris flows occurred again in 1984 and 1985 to further underscore the problem. At the same time, the U.S. Geological Survey (USGS) began a three-year study of the Wasatch Front under the National Earthquake Hazards Reduction Program (NEHRP). This program has greatly accelerated the production of geologic hazards information, and with the addition of an objective addressing implementation, has funded several projects aimed directly at aiding local governments in using geologic hazards information in planning.

One of these projects, sponsored by the UGMS, is termed the County Hazards Geologist Program. Although the UGMS has long advocated the consideration of geologic hazards in planning and been available to local governments to provide hazards information and review engineering geologic reports upon request, these services have not been fully utilized. Also, the UGMS has no regulatory authority to implement recommendations made in report reviews, and effective influence on land use can best be accomplished by geologists in local governments where decisions are made. Also, geologists at this level can become involved in projects earlier and avoid problems. In view of this, the UGMS acquired USGS funding under the NEHRP to place geologists in Wasatch Front county planning departments for a three-year pilot program. The USGS funded three geologists to cover five Wasatch Front counties (Weber-Davis, Salt Lake, Utah-Juab). The goals of these geologists are to: 1) compile geologic hazards information and produce maps to be used to delineate hazard areas where site-specific reports should be required; 2) review engineering geologic reports; 3) advise planners regarding hazards ordinances; and 4) provide geologic expertise as required. The county geologists are a part of the county planning department under direct supervision of the planning director, and the UGMS provides technical supervision and other support as needed. The geologists are also available to cities to perform the same services provided to the county. The project began in June 1985, and federal funding will expire in June 1988. At that time, it is hoped that counties will take over funding of the program and maintain the geologists as permanent members of the planning department staffs.

The county geologists work closely together and with the UGMS to provide a uniform, consistent approach to the application of geologic hazards information in land-use planning along the Wasatch Front. Differences in the operations of the various local government entities and in the type and relative importance of hazards result in some differences in approach from city to city and county to county. The following sections discuss the hazards and the steps being taken to implement geologic hazards information in the planning process by the county geologists for Weber-Davis, Salt Lake, and Utah-Juab Counties.

GEOLOGIC HAZARDS AND PLANNING

EARTHQUAKES

Introduction

Earthquakes pose the single greatest geologic threat to life and property along the Wasatch Front. Although no large, damaging earthquakes have occurred in the historical past in populated areas along the Front, the geologic evidence indicates that such an earthquake (Richter magnitude 7.0-7.5) occurs on the Wasatch fault about every 400-666 years or so (preferred average 444 years), with the most recent occurring 300 to 500 years ago (Schwartz and Coppersmith, 1984). Recent work has indicated that such earthquakes may occur more frequently on the Wasatch fault, and when considering that other faults in the area may generate large earthquakes, this estimate of recurrence is probably high.

Earthquakes are a particularly difficult problem in terms of planning because of the great variety of hazards they pose, and the technical complexity of the scientific and engineering information and difficulty in translating it into usable planning products. The principal earthquake hazards are ground shaking, surface-fault rupture, liquefaction and related ground failure, rock fall and other slope failure, tectonic subsidence, and dam failure inundation. Other hazards, such as production of seiches (waves in lakes), increases in ground-water discharge, and surface drainage diversions are locally important. Each hazard requires a different approach to assess its severity, probability of occurrence, and location, and each has different consequences. All of these factors must be considered in planning, and much effort under the County Hazards Geologist Program is being directed toward addressing earthquake hazards.

Ground Shaking

Ground shaking is the most widespread and frequently occurring earthquake hazard and will likely be responsible for the majority of earthquake-caused damage in the Wasatch Front in the future. Earthquake ground shaking is an extremely complex phenomenon. It is inescapable in terms of land-use because it may occur anywhere at any time. It may vary in severity from barely noticeable to very destructive depending chiefly on the magnitude of the earthquake, epicentral distance, and site conditions (soil type, depth to bedrock and ground water). The resulting extent of damage to buildings depends on building height and construction type as well as on the severity of shaking. Because of these factors, ground shaking hazards are generally addressed in building codes rather than in land-use planning ordinances. The Uniform Building Code gives minimum standards for construction in each identified seismic zone, and most of the Wasatch Front is in seismic zone 3. Enforcement of these codes is particularly important in construction of multi-story buildings, and structural engineers for tall buildings must generally consult an engineering seismologist to determine ground shaking parameters to be used in the building design.

Recent research by the U.S. Geological Survey (Hays and King, 1982) has shown that certain site conditions may greatly amplify ground shaking beyond that used in the development of minimum standards outlined in building codes. Studies indicate that the seismic waves of frequencies which particularly effect 2-7 story buildings are amplified most in central valley areas, with amplification decreasing toward mountain fronts. For waves particularly important to other structures, the data are less conclusive, but some amplification also occurs in central valley areas. Because of this, the county geologists are recommending that, as a minimum, building codes for seismic zone 3 are met and that site conditions be evaluated for multi-story buildings, particularly those in central valley areas.

Surface-Fault Rupture

Earthquakes are generated by ruptures along faults, and during large, deep-focus earthquakes the ruptures may propagate to the surface to form scarps. Evidence for large prehistoric earthquakes along the Wasatch Front is apparent from the numerous well-developed scarps along the Wasatch and other faults in the area (figure 1). The long-term recurrence estimate

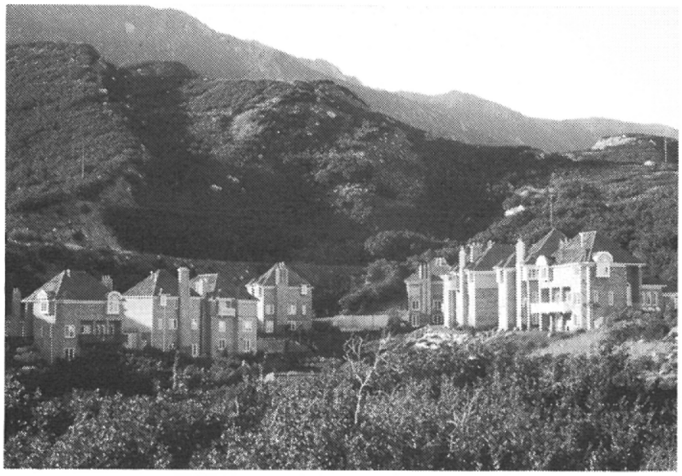

FIGURE 1. Scarps along the Wasatch fault in glacial moraines at the mouth of Little Cottonwood Canyon, Salt Lake County.

of large earthquakes (Richter magnitude 7.0-7.5) given in the introductory paragraph is taken from detailed studies of existing scarps along the Wasatch fault, including age-dating of individual faulting events that have occurred over the past 8000 years (Schwartz and Coppersmith, 1984). These studies have also indicated that major surface faulting generally recurs along the same traces, as indicated by existing scarps, and usually consists of about 6 feet or more of instantaneous offset of the ground surface. This and the fact that structures cannot be built to withstand surface faulting makes planning relatively straightforward. The U.S. Geological Survey is presently mapping existing fault scarps at a scale of 1:24,000, and the county geologists are recommending that detailed studies be performed for development proposed in the vicinity of these mapped scarps. These detailed studies need to accurately map existing scarps on or near the property so that standard setback guidelines from the tops and bases of scarps (modified from McCalpin, 1987) can be followed for placing permanent structures. If a developer finds the standard setbacks to be unacceptable, the option to perform more detailed subsurface investigations (trenching) and request variances is available.

Liquefaction and Related Ground Failure

Liquefaction may occur in saturated, silty and sandy sediments as a result of strong ground shaking. The Wasatch Front is fortunate in that maps which assess the liquefaction potential have been or are being produced for all counties (Anderson and others, 1982, 1986a, 1986b). These maps are based on a region-wide evaluation of existing soil and ground-water conditions and an assessment of the probability that ground shaking sufficient to cause liquefaction will occur. Once liquefaction occurs, the ground may fail in one of three ways depending on surface slope: 1) loss of bearing strength (0-0.5 percent slope), 2) lateral spread (0.5-5 percent slope), and 3) flow landslide (greater than 5 percent slope).

Large areas of moderate to high liquefaction potential occur in central parts of Wasatch Front valleys, particularly surrounding Utah and Great Salt Lake. In these areas it is recommended that detailed evaluations be performed for proposed major construction. In general, such studies are not required for relatively light-weight single family dwellings.

Other Earthquake Hazards

Study is presently underway to gather data and translate existing information for use in planning as it relates to other earthquake hazards. Maps depicting seismic slope stability (Davis and Salt Lake Counties only) and tectonic subsidence accompanying surface faulting have been produced (Keaton and others, 1987; Keaton, 1987) and are being evaluated in terms of recommendations for use in planning. Rock-fall hazard maps by the UGMS (Case, 1987) are being incorporated into mapping efforts by the county geologists. The U.S. Bureau of Reclamation has produced maps showing inundated areas accompanying failure of dams along the Weber, Ogden and Provo Rivers. Little information is available on other hazards, and maps depicting seiche hazards or hazards related to changes in surface or ground-water regimes during earthquakes are not planned.

LANDSLIDES

The term landslide is used here to include all slope failures other than debris flows in channels and on alluvial fans, and rock falls. Landslides thus include everything from the massive Thistle landslide (technically an earth flow) to the small, shallow, hillside failures (technically termed debris slides) in 1983 throughout Davis County which, in some cases, mobilized into debris flows which reached Farmington and Bountiful. Landslides occur both in bedrock and colluvium of the steep Wasatch Range and in unconsolidated deposits, chiefly of Lake Bonneville, in the valley portions of the Wasatch Front. In the Wasatch Range, several geologic units are particularly prone to landslides. These include: 1) the Tertiary-age Norwood Tuff and Wasatch Formation in Weber County; 2) colluvium developed on the Precambrian Farmington Canyon Complex in Davis County; 3) the Triassic Ankareh, Jurassic Preuss, and Cretaceous Kelvin Formations in Salt Lake County; and 4) the Mississippian-Pennsylvanian Manning Canyon and Cretaceous-Tertiary North Horn Formations in Utah and Juab Counties. In 1983, over 65 landslides occurred in Davis County from Bountiful to Farmington (Anderson and others, 1984), and over 90 have been mapped in Salt Lake County covering the period 1983-1985. Fortunately, most of these occurred in unpopulated, undeveloped mountainous areas and damage was restricted to roads and utility corridors. The most costly of the mountain landslides was the Thistle landslide in Utah County which dammed the Spanish Fork River, cutting off major east-west rail and highway corridors, inundating the town of Thistle, and costing over $250 million. Landslides also damaged homes and roads in Emigration Canyon in Salt Lake County. In Utah County, landslides in Provo Canyon have repeatedly damaged the highway and the Ohlmstead Aqueduct, which brings water from Deer Creek Reservoir.

In terms of urban planning, however, landslides in the unconsolidated deposits in the highly developed valleys of the Wasatch Front pose a much greater problem than do those in the mountains. Steep bluffs flank many drainages as a result of streams cutting down into lake deposits as Lake Bonneville receded beginning about 15,000 years ago. Many of these bluffs, particularly along the Ogden and Weber Rivers in Weber and Davis Counties, are very unstable. The bluff on the north side of the Weber River is known as the Washington Terrace landslide complex (Pashley and Wiggins, 1972). A number of landslides have occurred here in recent years, including the 1981 "railroad landslide" (figure 2) which derailed eight Union Pacific railroad cars and damaged three Utah Power and Light transmission-line towers (Gill, 1981). Five flat-cars carrying U.S. mail, as well as the toe of the landslide, came to rest in the Weber River, diverting the flow and flooding four homes (Gill, 1981). A similar landslide several hundred yards east of the "railroad landslide" on property owned by the Gibbons and Reed Company mobilized into a mud flow that buried an undeveloped part of the Weber River flood plain in 1983.

FIGURE 2. "Railroad" landslide in 1981 in the Washington Terrace landslide complex along the Weber River.

The bluff on the south side of the Weber River is known as the South Weber landslide complex. In February 1983, seven houses which had been built on an old landslide just north of the Weber/Davis County line in Riverdale were damaged when renewed movement on the landslide occurred. One of the houses (figure 3) which was heavily damaged had been on the toe of the landslide for about 40 years before the 1983 event occurred. Old landslides may remain stable for long periods of time, but generally are highly susceptible to future landsliding, particularly if disturbed by man. The Weber-Davis Canal is frequently damaged by landslides occurring along steep slopes in the South Weber landslide complex.

FIGURE 3. Damaged house on the toe of the 1983 South Weber Drive landslide in Riverdale.

Similar landslide complexes occur along both sides of the Ogden River just downstream from the mouth of Ogden Canyon. On March 9, 1987, renewed landslide activity occurred along the east flank of an older landslide behind Rainbow Gardens on the south side of the Ogden River. The landslide destroyed a steel power-line tower and caused a loss of power to much of the east bench area of Weber County. Along the mountain front between the Ogden and Weber Rivers, a landslide on the north side of Combe Road in the Uintah Highlands area of southern Weber County has been active for a number of years. The toe of the landslide has annually encroached onto Combe Road, requiring removal. During winter, water from the toe of the landslide has frozen on the road causing a number of automobile accidents. In 1986, two longitudinal "finger" drains were placed in the toe of the landslide to stabilize the slide. Although conditions wet enough to provide a good test of the mitigation attempt have not occurred, the landslide has been inactive and water was kept off Combe Road for the first time in a number of years.

In Davis County, landslides are common along incised drainages, particularly in east Layton, where a number of homes have been damaged. In 1986, landslides occurred in Layton along the North and Middle Forks of Kays Creek and along Kays Creek below the confluence of the three forks, and in unincorporated Davis County along an unnamed drainage just north of Ward Road and west of Highway 89.

Slope instability has historically caused problems in the Salt Lake area as well, and examples of the consequences of poor building and siting practice with regard to unstable slopes include two homes destroyed by landslides, one in the Little Cottonwood Creek area in 1984 (figure 4), and another in Emigration Canyon in 1985. Residential sites in City Creek Canyon, Olympus Cove, Canyon Cove, the Johnson's Hollow and Pinecrest areas of Emigration Canyon, and the Heugh's Canyon drainage in the southeast part of the county have been threatened or damaged by landslides. Preliminary data on all landslides in Salt Lake County indicate that over 75 percent occur on hillsides with slopes greater than 30 percent (figure 5).

Both Utah and Juab Counties have large areas of landsliding and potentially unstable slopes in valley areas, and the east

FIGURE 4. Home destroyed by a landslide in 1984 along Little Cottonwood Creek in Sandy.

bench of Provo City has been particularly affected. Renewed movement in 1983 in part of a prehistoric landslide buried 15th East Street and threatened neighboring homes (figure 6). In the Sherwood Hills area of north Provo, landslides have damaged homes and roads as the underlying Manning Canyon Shale has failed. Smaller landslides are found in bluffs along rivers and are a particular problem in cut slopes, but have not been as extensive as in Weber and Davis Counties.

In planning for landslide hazards, the first step by the county geologists has been to compile detailed landslide inventory maps. Based on preliminary data for Salt Lake County, it appears that landslides are most common on slopes above 30 percent, the value commonly already used by local governments to restrict or prohibit development based on other considerations such as maximum road grades, need for extensive cut and fill, and erosion/revegetation concerns. The county geologists are recommending slope stability studies, with recommendations for mitigating any hazards found, prior to development on all slopes exceeding 30 percent providing such development is not already prohibited by ordinance. Additionally, areas of landslide-prone geologic units known to fail at lower slopes, either naturally or due to man's influence, will be delineated based on slope percent and extent of existing landslides as areas also requiring slope stability studies.

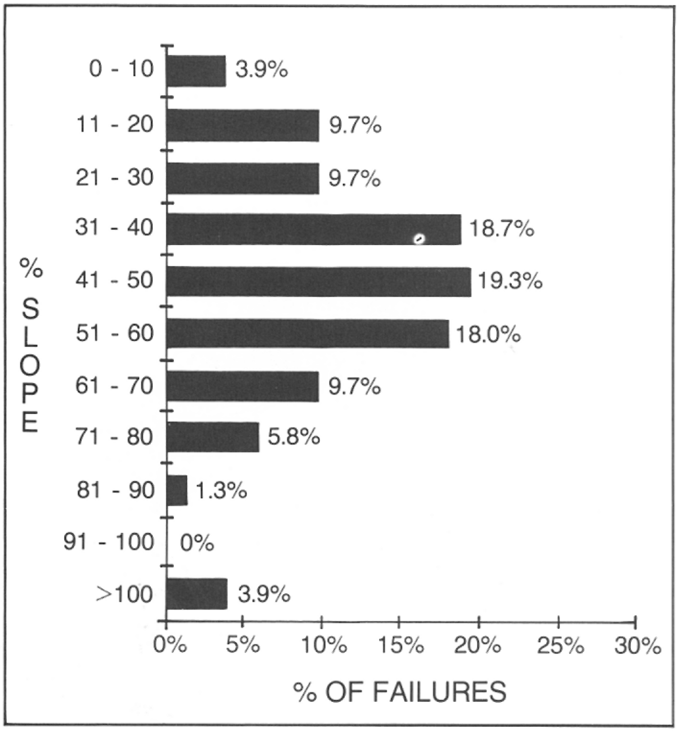

FIGURE 5. Relationship between slope steepness (percent) and number of slope failures, Salt Lake County.

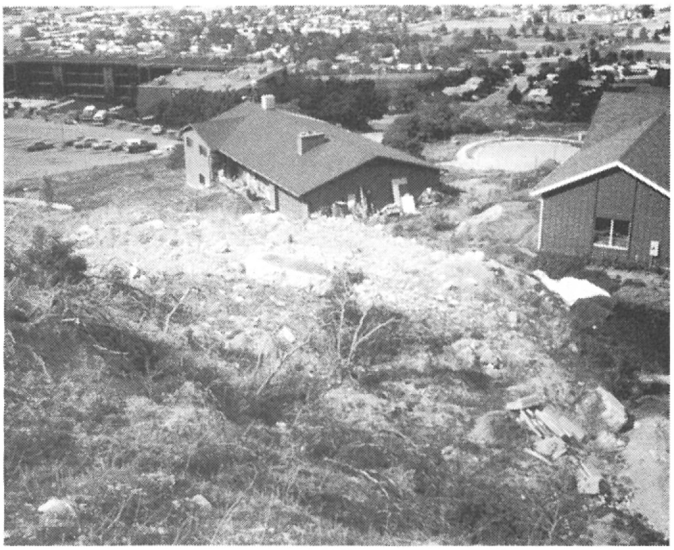

FIGURE 6. Landslide which blocked 15th East Street and threatened homes in 1983 in Provo.

DEBRIS FLOWS

Debris flows occur as a result of landsliding and erosion during cloudburst storms and rapid snowmelt. In Davis County, many debris flows occurred during the 1920s and 1930s as a result of erosion during summer cloudbursts. In 1983 and 1984, debris flows occurred during the spring as water from rapid snowmelt generated landslides which mobilized into debris flows (figure 7). Davis County has been particularly prone to debris flows because of the weathering characteristics of the Precambrian Farmington Canyon Complex, although geological evidence exists for potentially destructive debris flows all along the Wasatch Front. Table 1 gives an indication of the extent of the hazard in Davis County, and as a result a comprehensive effort has been undertaken to mitigate the problem, chiefly through construction of debris basins.

In Weber County, debris flows or debris floods have occurred along Waterfall Canyon in 1923; the Ogden River in 1888, 1923 and 1980; Coldwater Canyon in 1983; and Skull Crack Canyon in 1986 (Wieczorek and others, 1983; Lowe and Kaliser, 1986). Debris flows also occurred in Salt Lake, Utah, and Juab Counties but were restricted to canyon areas such as Mill Creek, Big Cottonwood, and American Fork Canyons. Little damage occurred in populated areas, and damage was principally to roads.

Continued on page 10

UTAH EARTHQUAKE ACTIVITY

By Ethan D. Brown

UNIVERSITY OF UTAH SEISMOGRAPH STATIONS
DEPARTMENT OF GEOLOGY AND GEOPHYSICS

THE University of Utah Seismograph Stations records an 81-station seismic network designed for local earthquake monitoring within Utah, southeast Idaho, and western Wyoming. During January 1 to March 31, 1987, 152 earthquakes were located within the Utah region, including 57 greater than magnitude 2.0. The epicenters in figure 1 show earthquake activity scattered throughout Utah's main seismic region with significant localized clustering. The largest earthquakes during this time period, M_L 3.7, occurred on February 25, and March 5, and were located respectively 32 km WNW of Logan in northern Utah and 90 km east of Vernal in eastern Utah. The northern earthquake was reported felt in Tremonton, Utah, and other areas of Box Elder county. Three felt earthquakes of about the same magnitude originated in the same source area during the last report period. The March 5 earthquake was felt in areas in and about Duchesne within the Uinta basin. Two small earthquakes, M_L 2.7 and 2.9, occurred on March 11 about 3 km south of Manti (50 km NE of Richfield), and were felt by numerous people in Manti.

About half (75 out of 152) of the earthquakes recorded during the study period occurred in four spatial clusters labeled in figure 1. The largest (1) is WNW of Logan and includes 43 earthquakes ($M_L \leq 3.7$) that occurred chiefly during February and March. This cluster represents a continuation of activity that began in September of 1986 which has produced six felt events with magnitudes in the mid-three range. A joint seismological-geological study of this area (at the north end of the Blue Spring Hills) is currently being carried out by the University of Utah Seismograph Stations and the Utah Geological and Mineral Survey. Further west, north of the Great Salt Lake, a smaller cluster (2) of 12 events ($M_L \leq 3.4$) occurred in mid-March. To the south, two small clusters of 11 (3) and 9 (4) earthquakes ($M_L \leq 2.8$ and 2.3, respectively) were located 40 km SW of Price and 50 km NE of Richfield.

During April 1 to June 1, 1987, 98 earthquakes were located within the Utah region, including 39 greater than magnitude 2.0. The epicenters in figure 2 show earthquake activity scattered throughout Utah's main seismic region with two localized clusterings north of the Great Salt Lake. The largest earthquake during this time period, M_L 3.6, occurred on April 1, and was located 35 km WNW of Logan in the easternmost cluster north of the Lake. This earthquake was reported felt in Tremonton, Utah, and other areas of Box Elder County. Prior to the shock, six felt earthquakes of about the same magnitude had originated in the same source area since September 1986. In southwestern Utah, 5 km east of Cedar City, an earthquake occurred on April 3 at 11:24 pm and was strongly felt in Cedar City.

Of the two clusters located north of the Great Salt Lake, the larger includes the felt earthquake WNW of Logan mentioned above, and 21 earthquakes ($M_L \leq 3.6$) that occurred cheifly during the first week of April. This cluster represents a continuation of activity that began in September of 1986. The second cluster 45 km to the west includes 15 events ($M_L \leq 3.4$) that occurred in the last half of April.

Additional information on earthquakes within Utah is available from the University of Utah Seismograph Stations, Salt Lake City, Utah 84112; telephone (801) 581-6274.

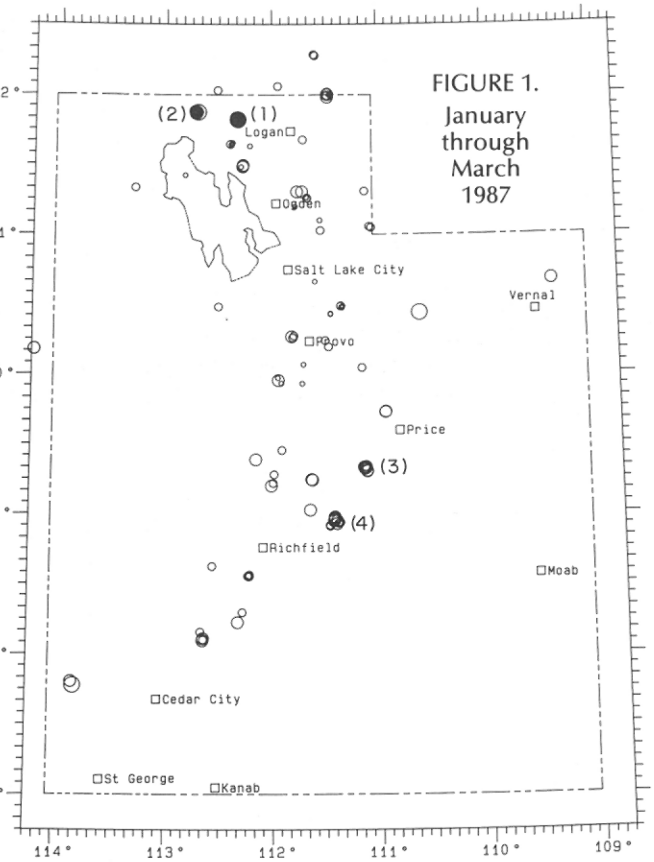

FIGURE 1. January through March 1987

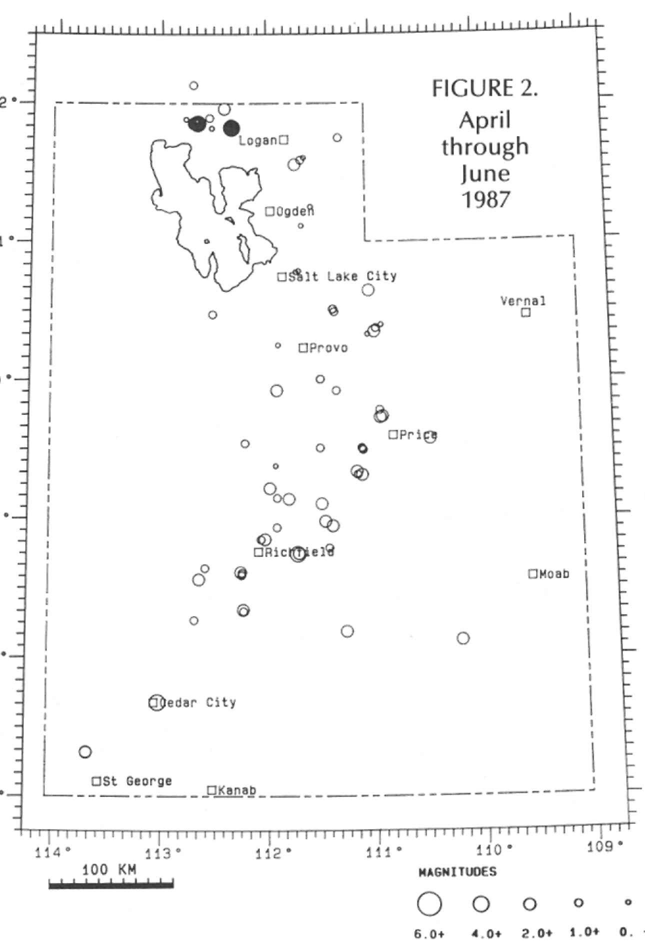

FIGURE 2. April through June 1987

BIG COTTONWOOD CANYON FLUME DAMAGED BY ROCKFALL DUE TO CLOUDBURST

by William F. Case

Urban development in mountainous terrane is beset with geologic hazards because of steep slopes and bedrock exposures. Recent studies by Keefer (1984) have indicated that rockfall is the most common and dangerous geologic hazard (the third leading cause of death) triggered by an earthquake. Historic evidence indicates up to 10,000 rockfalls occur during a major earthquake (Keefer, 1984). Rockfalls are also caused by many other diverse phenomena such as cloudburst precipitation. The Utah Geological and Mineral Survey is presently delineating areas susceptible to rockfall hazard and documenting damaging rockfall occurrences in the Wasatch Front area (Case, 1987). Such information is essential to urban planners who are responsible for personal safety and property protection as communities expand into foothills and canyons.

A cloudburst precipitation event at 1:00 pm, on 21 July, 1987, triggered rockfalls in Big Cottonwood Canyon, Salt Lake County, Utah (Salt Lake Tribune, 22 July, 1987). At 1:00 pm rockfall clasts smashed a wooden flume owned by Utah Power and Light Company (UP & L) in four places and released a water flow of approximately 40 cfs (1 m^3/s) of water, until it was shut off shortly after the breach, according to a UP & L employee. The flow scoured a gully and deposited an alluvial fan of a few cubic meters of soil which spread across the canyon road and about 100 feet (30 m) along the road.

The site is located west of the UP & L Stairs Power Plant. The quartzite rockfall clasts originated from the Big Cottonwood Formation (Crittenden, 1965), about 1300 feet (400 m) upslope and 850 feet (260 m) above the flume. A scree slope at an angle of repose of about 25°, which consists of 6-inch (15-cm) and smaller argillite and quartzite clasts, extends from the argillite bed which underlies the quartzite outcrop to within a few yards (meters) of the flume. A few 3-6 foot (1-2 m) quartzite boulders, similar to those that breached the flume, rest securely on the scree slope. The rockfall clasts that crashed into the flume have discoid to thickly bladed shapes. Clast surfaces showed no definite joint planes, but rather had irregular breaks, some of which were fresh. There were few clearly marked rockfall clast trails through the oak brush which separates the flume and the scree on a steep slope. A 4-inch (10-cm) in diameter oak tree trunk was split by a rockfall clast at a height of about 6 feet (2 m) above the ground, presumably when the clast bounded off the scree slope. The clast landed on the downslope side of the flume, a trajectory path of about 50 feet (15 m) in the air. The rockfall clasts that smashed into the flume on 21 July, 1987, probably came from the quartzite outcrops above the flume; the large clasts on the scree slope are slightly buried and appear to be stable. Not all the clasts bounced on to the flume. Total weight of the clasts is estimated at approximately 2-3 tons (2-3 mt). The mechanism of failure at the outcrop is not known. Many older clasts, identified by their more weathered surfaces and settlement into the soil, are evident in the study area. The process is not new and is not through.

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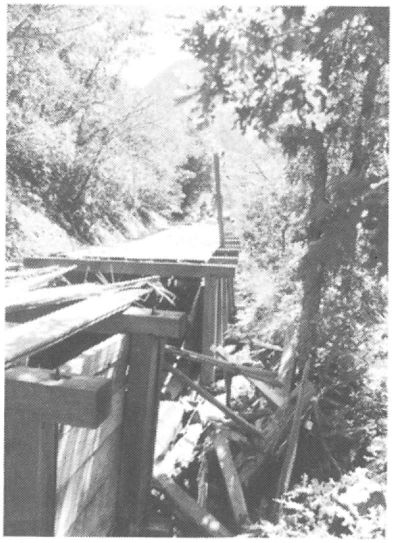

Rockfall clast has rolled through the 5 x 5-foot (1.5 x 1.5-m) flume. In the background, UP&L personnel are repairing a break.

Gully scoured by flume water and resulting alluvial fan at the base of the slope. The fan has been bladed off the Big Cottonwood Canyon road.

Tree split by rockfall clast. Trunk diameter is approximately 4 inches (10 cm). Broken piece is resting on flume near the rockfall clast which damaged the flume on the downslope side.

Rockfall clast which broke on impact with the upslope side of the wooden flume. The maximum diameter of the clast before impact with the 8 x 8-inch (20 x 20-cm) beam was approximately 6 feet (2 m).

GEOLOGIC HAZARDS
Continued from page 7

Debris flows present the greatest hazard when they reach canyon mouths in developed areas. Such areas where this is likely to occur can be determined from the historical record and can be recognized in the geologic record by the occurrence of steep, bouldery, alluvial-fan deposits overlying Lake Bonneville materials at mountain fronts. The county geologists are compiling maps of these areas and are recommending that an analysis of the debris-flow hazard and possible mitigating measures be performed prior to development. In determining the need for such reports, the county geologists will consider the stability of hillslope materials in source areas and the presence of debris basins at canyon mouths.

FIGURE 7. Debris flow at the mouth of Rudd Canyon in Farmington in 1983.

Table 1. Historical Davis County debris flows (Marsell, 1972; Wieczorek and others, 1983; U.S. Army Corps of Engineers, 1984; Davis County Flood Control, 1987).

Drainage	Years	Damage
Dry Fork, Kays Creek	1984	house damaged
Middle Fork, Kays Creek	1947, 1953	
South Fork, Kays Creek	1912, 1923, 1927, 1945, 1947	
North Fork, Holmes Creek	1983	
South Fork, Holmes Creek	1917	
Baer Creek	1983	
Shepard Creek	1983	
Farmington Creek	1878, 1923, 1926, 1930, 1947, 1983	1923 - 7 deaths, several houses damaged
Rudd Creek	1983	35 houses damaged, 15 severely
Steed Creek	1923	
Davis Creek	1878, 1901, 1923	
Ricks Creek	1923, 1929, 1930	1923 - 1 house damaged, 1930 - 1 house damaged
Parrish Creek	1930 (several events)	several houses destroyed, school damaged
Stone Creek	1983	houses damaged
Mill Creek	1983	

ROCK FALLS

Loose rocks on hillsides and in outcrops commonly are dislodged and roll down slopes during storms and earthquakes. Falling rocks damaged parked cars and homes in Challis, Idaho, during the 1983 Borah Peak earthquake, and reports of clouds of dust rising from canyons due to rock falls and slides are very common during earthquakes. As expected, the hazard exists chiefly in canyons and along the steep front of the Wasatch Range and other mountain ranges.

Rock fall is an almost annual occurrence in Ogden Canyon during periods of heavy precipitation, particularly near Pineview Dam. A rock fall was also reported east of Farmington City during a heavy rain storm about five or ten years ago (Max Elliott, Davis County Surveying, oral communication, May 20, 1987).

Recently, a family cookout in the upper Avenues area of Salt Lake City was disrupted when a 2-foot diameter boulder rolled from the steep hillslope above the home and smashed the barbecue grill. Rock falls are a continuing and very dangerous hazard along the access roads and entrances to underground storage vaults at the mouth of Little Cottonwood Canyon. The U.S. Geological Survey is presently conducting research on rock-fall mechanisms and hazards in the upper east bench in Salt Lake County.

Last year a rock fall from a ledge in Provo Canyon struck the Olmstead aqueduct after rolling over 1500 feet (figure 8). Water escaping from the holes in the pipe washed out the access road and contaminated Provo City's drinking-water springs below the pipe in Provo Canyon.

FIGURE 8. Rock-fall boulder which ruptured the Olmstead aqueduct in Provo Canyon in 1986.

Rock fall is a very site-specific problem not easily evaluated at a regional level. As discussed under Earthquake Hazards, rock-fall susceptibility maps by the UGMS (Case, 1987) have been prepared for the west-facing front of the Wasatch Range and will be used to indicate where detailed studies are needed along the front. It will be necessary to address the hazard for all construction in canyons because at this point it is not practical to produce regional rock-fall hazard maps for these areas.

FLOODING

Stream flooding has occurred frequently in all counties, but Salt Lake County was probably hit hardest in 1983 as streams were diverted onto streets to handle the excess flow. The hazard has been significantly reduced in recent years by the construction of flood retention structures, improvements in storm sewer systems, and stream channel improvements. The rising Great Salt Lake, however, has provided a new challenge. Much damage has been caused to facilities in the lake and to shoreline areas of western Weber and Davis County and northern Salt Lake County. Plans to control the lake level are now underway through the pumping project, and various diking alternatives are being considered. Weber County, Farmington City, and Woods Cross have taken or are taking steps such as resolutions or master plan elements to control development below appropriate elevations to help limit future damages due to the rising Great Salt Lake. In Utah County, the rise of Utah Lake caused significant damage to shoreline facilities and I-15 (figure 9). Recent dredging of the Jordan River and modifications to outlet works are designed to preclude such flooding in the future. Flooding problems are not being specifically addressed by the county geologists because these are handled by county flood control agencies.

FIGURE 9. Flooding of Interstate 15 by Utah Lake in the Spanish Fork area in 1984.

OTHER HAZARDS

Other geologic hazards along the Wasatch Front include expansive and collapsible soils, shallow ground water, and avalanches. Expansive and collapsible soils have been reported in all Wasatch Front counties. In many cases, the same rock units subject to slope failures weather to form expansive soils, particularly the Manning Canyon Shale in Utah County. Orem City has experienced foundation, road, and sidewalk cracking caused by such expansive soils. Collapsible soils may be less widespread but are more difficult to identify. Soil collapse is due to hydrocompaction (loss of volume upon wetting), and Nephi in Juab County and Pleasant Grove in Utah County have both had subsidence problems apparently caused by collapsible soils. Subsidence in the Bountiful area has caused damage to at least 40 residential properties. Two hypotheses to explain the damage include: 1) collapsing of the soil fabric (due to hydrocompaction) in the near-surface materials, and 2) slow, discontinuous downslope movement of a large block of earth (Kaliser, 1985). Subsidence in the form of sink holes occurred in Clinton City in 1987. Maps are planned to indicate where soil problems have occurred and, based on soil mapping by the U.S. Soil Conservation Service, where they may be expected. These will be used to stress the need for standard soil foundation investigations prior to construction in these areas.

Shallow ground water is a problem in much of western Weber and Davis Counties, central and northwestern Salt Lake County, and central Utah County. In addition to flooding basements and septic tank drainfields, shallow ground-water problems have included: 1) a motel swimming pool damaged when rising ground water levels "floated" the empty structure in Salt Lake County, and 2) movement of contaminants such as gasoline from leaking underground storage tanks into basements and sewer lines in all counties. Maps showing depth to shallow ground-water have been prepared as part of liquefaction potential studies by Anderson (1982, 1986a, 1986b), and these will be used to stress the need to address ground-water problems in soil foundations studies.

Avalanches are common occurrences in mountainous regions, and several cabins and other structures, including facilities at Bridal Veil Falls, were damaged by avalanches during the winters of 1985 and 1986 in Utah County (figure 10). As a result, the residents of the Sundance area where some of the damage occurred hired a consultant to delineate avalanche paths and hazard areas. Avalanche hazards exist in all of the steep-walled canyons east of the Wasatch Front and must be considered in all construction in such areas. No avalanche hazard maps are being prepared by the county geologists; however, site-specific studies for all canyon development will be recommended.

FIGURE 10. Cabin hit by avalanche near Sundance in 1986 causing over $1.5 million in damage.

ROLE OF THE COUNTY HAZARDS GEOLOGISTS IN PLANNING

The purpose of the County Hazards Geologist Program is not only to produce and compile hazards maps and information but to aid local government planners in using the information to reduce hazards. This has been accomplished in many ways, with emphasis during the initial phases of the program on the development and strengthening of hazards ordinances. The general approach to be used in such ordinances was discussed earlier and is outlined in UGMS Circular 79. Jerold Barnes of the Salt Lake County Planning Department has drafted a geologic hazards ordinance which follows this approach closely, and it is being used by various Wasatch Front cities and counties as a model. Although drafting and adoption of a new ordinance is a time-consuming process, it is now underway in Weber, Salt Lake, and Utah Counties. The cities of Washington Terrace and Riverdale in Weber County are also working on master plan elements and ordinances addressing geologic hazards. Based in part on recommendations from slope stability data gathered during the landslide inventory (figure 5), the maximum buildable slope limit in Salt Lake County was reduced from 50 percent in Forestry Zones and 40 percent in the Hillside Protection Zone, to a county-wide 30 percent limit.

Many of the larger cities in all counties have already adopted ordinances addressing geologic hazards, and the county geologists are aiding them in implementing these ordinances by providing the needed geologic expertise in identifying hazard areas and reviewing engineering geologic reports. Because hazard maps are not yet complete, city and county planners frequently request that the county geologist determine the necessity of requiring engineering geologic reports on a site-specific basis for proposed subdivisions prior to planning commission hearings. Completion of an engineering geologic report for a site does not necessarily mean that hazards affecting the site will be avoided or mitigated. Engineering geologic reports reviewed by the county geologists have commonly been inadequate when initially submitted and must be revised and amended before they are acceptable (Nelson and others, 1987).

All services of the county geologist are also available to cities, and assistance has been given to Salt Lake City planners in implementing their new site development ordinance. Although in the past many structures have been allowed to be constructed in the Wasatch fault zone, Salt Lake City's new ordinance prohibits construction on active faults. The first development to be directly affected by this new ordinance was proposed on Dresden Lane, near 550 South 900 East, in Salt Lake City. It was planned to place a four- and five-story apartment building in an area straddling the East Bench fault, and as part of the building-permit issuing process the county geologist requested a detailed geologic report focusing on the surface-fault rupture hazard at the site. This included accurately locating the fault, determining the recency of last faulting if possible, and recommending a suitable setback for siting the structures if the fault was determined to be active. Exploratory trenches by the developer's consultant exposed several faults trending diagonally through the site and directly beneath the largest proposed apartment structure. After submittal, review, and revision of the consultant's reports, it was determined that essential information on the time of last movement and frequency of faulting events could not be determined because the upper part of the geologic record had been removed by previous site grading. However, it was shown that a minimum of about 25 feet of offset had occurred since about 20,000 years ago, and because of the potential serious consequences of fault rupture across this site, Salt Lake City considered the faults active and required that buildings not straddle it. This made the site plan and engineering work already completed unusable, and the site was eventually abandoned for high density dwellings by the developer. Several important lessons were learned from this experience: 1) the county geologist can offer specialized expertise and play an important role in aiding city and county planners in the development process, 2) it is important for developers to recognize that geologic hazards are a critical consideration and that geologic studies should be completed prior to site design, and 3) a geologic reconnaissance done before purchasing land for development may save considerable expense in assessing its suitability for the intended land use.

In addition to the city and county planning departments, several other departments/agencies have used the services of the county geologists. County flood control and emergency management agencies have requested aid in the prediction of and response to hazard events, particularly flooding and landsliding. The county health departments have requested on-site investigations to evaluate potential soil and ground-water problems as they relate to septic tank systems. The county engineer's office has asked for reviews of sites for bridges and help in mitigating hazards affecting county roads and public facilities. Local building officials have requested assistance in inspecting excavations for evidence of faulting or ground failure, in evaluating unstable slopes, and in recommending mitigation needs. Davis County, North Salt Lake, Eden, Layton City, and Salt Lake County have used the county geologist to evaluate geologic hazards affecting proposed or existing public facilities, principally water storage tanks. The county geologist aided Davis County in evaluating the gravel resource potential and determining the best use of county property on the Salt Lake Salient. Davis County also requested an evaluation of geologic hazards affecting the North Davis Refuse Disposal and new Burn Plant sites. Extensive investigations and report reviews regarding the engineering geologic aspects of the Provo City landfill site west of Utah Lake were performed for Provo City, and geologic hazards on city-owned property surrounding the Payson Golf Course have been evaluated to determine suitability for development.

An important service is also provided to the public by the county geologists. Prospective real estate buyers seeking hazards information often visit the planning office where hazards maps, geologic and emergency preparedness literature, and geologic advice are available. Community awareness about geologic hazards has also been increased through slide-lecture programs the geologists have presented to local community councils and civic groups.

The county geologists also assist in other hazards projects underway in the counties. In Salt Lake County, West Valley City has recently completed phase one of an earthquake hazards reduction study involving a computerized compilation of seismic hazards data for the city for use in planning. In another project, researchers from the University of Utah Geography Department are integrating seismic hazards data into a computer-based geographical information system for use in seismic risk assessment throughout Salt Lake County. The Utah State Division of Comprehensive Emergency Management and Utah County initiated a comprehensive hazard mitigation project in the Provo-Orem area to aid emergency response personnel and planners. This project included geologic hazard map compilation and interpretation by the county geologist, UGMS, and other agencies (Robison and others, 1987). Copies of the project maps will be housed with the county geologist for dissemination and updating.

SUMMARY AND CONCLUSIONS

Few moderate to large earthquakes have been experienced by residents of populated parts of the Wasatch Front. Because of this, some people are not convinced that a real hazard exists. Consideration of these hazards has also been impeded by a lack of general hazard maps, and the fact that detailed investigations necessary to plan properly for earthquake hazards can be expensive and require specialized expertise. Landslide and other hazards occur more frequently and thus have received greater acceptance in planning, but still much remains to be done. One of the goals of the county geologist program is to establish straightforward, minimum guidelines which can be easily followed and which will significantly reduce the risk without requiring expensive detailed studies. In this way, only those proposing major or critical facilities construction or those that will not accept a reasonable degree of conservatism and insist on building in hazardous areas as close to a fault or as high on the mountain front as possible, will be required to perform these studies. The ultimate goal is to promote safe development through long-range planning based on the best available information without incurring unreasonable added expense.

The County Hazards Geologist Program is a very important part of both the UGMS and USGS efforts to implement geologic hazards information in long-range land-use planning to reduce losses of both property and lives. The program was originally conceived as an experiment to determine if a geologist at the local government level could be effective in carrying out these goals, and it is believed that this has been done very successfully. Great progress has been made in the production of "translated" hazards information usable by planners and in the development and implementation of effective geologic hazards ordinances to protect people from life loss and property damage due to geologic hazards. However, the effort has just begun and must continue if full implementation is to be realized.

Because the federal funding for the county geologist program expires in June 1988, it will be necessary for county governments to take over funding of the geologists' salaries if they wish to continue the program. The county planning departments housing the geologists have expressed their support for the program and plan to include the geologists in their FY 1988 budget proposals. If the counties retain the geologists, the UGMS will continue its support by providing technical assistance as it has from the beginning. Although these are difficult times for local governments and the pressure to cut budgets is great, we believe that an opportunity to acquire a trained, experienced geologist familiar with the county exists now that may not be available again. By continuing this valuable program, Wasatch Front counties can confirm their commitment to the protection of their citizens and establish the Wasatch Front as a leader in the responsible and effective use of geologic hazards information to reduce hazards.

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EXTRA, EXTRA

*Congratulations...*Doug Sprinkel, currently Senior Geologist of Applied Geology Program has accepted the position of Deputy Director, presently held by Don Mabey. Don is leaving after five years of service and plans to spend a major share of his time at the new place he recently built near Moab, Utah.

*Appointment...*Bill Lund has been appointed by the Salt Lake County Commission to serve on the Technical Committee of the Salt Lake County Wasatch Canyon Master Plan program.

*Other appointments...*F. Beach Leighton and Brian J. Skinner have been appointed to the board of trustees of the Geological Society of American Foundation.

Continued from page 2

creating additional hazards to those comunities. Control of the lake by a series of inter-island dikes also could lower the lake level along its eastern shore but would create risks to life safety should a portion of the dike fail.

Lesson #4: Role of geologists

The wet cycle has provided many opportunities for UGMS staff and other members of the earth-science community to make a difference to individuals, their communities, and our State. A well-trained professional, at the right place at the right time, can save thousands of dollars of damages to structures or can provide advice on how to recover, redesign or rebuild. The best preparation for UGMS is well-trained staff who can act effectively when emergencies arise. The emergencies also create a political environment that is receptive to appreciating, respecting, and planning for geologic hazards. Utah is in many ways a small state and the response last year to geologic hazards was remarkably personal, almost one-to-one. Decisionmakers at the local level appeared the most likely to ask for and use geologic information to see how it could help them avoid problems in the future. It was an exciting time for the UGMS. I'm not looking forward to the next wet cycle, but I know we're better prepared now and can be even better prepared in a few years if we take advantage of what we have learned. ∎

GREAT SALT LAKE LEVEL

Date (1987)	Boat Harbor South Arm (in feet)	Saline North Arm (in feet)
May 1	4211.70	4210.95
May 15	4211.65	4210.85
Jun 1	4211.60	4210.75
Jun 15	4211.55	4210.70
Jul 1	4211.20	4210.35
Jul 15	4210.90	4210.05
Aug 1	4210.70	4209.85
Aug 15	4210.35	4209.65

Source: USGS provisional records.

GEOLOGIC PROJECTS IN UTAH

Prepared by UGMS Staff, 1987

The Utah Geological and Mineral Survey inventories the geologic resources of Utah, identifies hazards, maps the geology, and provides information to decision-makers and governmental agencies. This listing of current projects indicates the diversity and scope of UGMS studies. In addition are the projects already in progress such as contract mapping, USGS coal information, industrial minerals information, site investigations, and others.

County(ies)	Type of study	Location	Map scale	Geologist/Investigator
Box Elder	geologic mapping	Brigham City and Bear River City quads	24,000	Jensen, M.E.
Box Elder, Cache, Davis, Weber	petroleum potential	northern Wasatch Front	250,000	Kerns, R.
Box Elder, Millard, Beaver, Davis, Iron, Juab, Salt Lake, Tooele, Utah, Washington, Weber	petroleum geology	Great Basin	variable	Kerns, R.
Davis	Lake Bonneville sediments	Antelope Island		Atwood, G; and others
Davis	petroleum potential	Antelope Island		Brandt, C.J.
Davis	Quaternary mapping/ engineering geology/ geologic hazards	Antelope Island	24,000	Christenson, G.; Case. W.
Davis	sand and gravel inventory	Antelope Island	24,000	Davis, F.D.
Davis	geologic mapping	Antelope Island	24,000	Doelling, H.H.; and others
Davis	saline minerals	Antelope Island		Gwynn, J.W.
Davis	engineering geology/geohydrology	Antelope Island		Klauk, R.H.
Davis, Washington, Wasatch	environmental/engineering geology	countywide		Mulvey, W.
Duchesne	engineering geology	SW Uintah Basin		Lund, W.R.
Emery, Carbon	coal: Vickers microhardness, dynamic (rebound) scleroscopic hardness	central Utah		Hucka, B.
Emery, Carbon	correlation study: stratigraphic petrographic, structural	central Utah		Hucka, B.; Keith, A.; Sommer, S.N.
Emery, Carbon Sanpete	cleats study; origin and distribution in Utah coal seams	central Utah		Hucka, B.; Sommer, S.N.
Garfield, Wayne	coal folio, USGS cooperative	Henry Mtn. Basin		Keith, A.
Grand	geologic mapping	Arches Nat'l Park	24,000	Doelling, H.H.
Grand	engineering geology	Castle Valley		Case, W.F.
Grand	subsurface geology, petroleum geology	eastern Utah	100,000	Kerns, R.
Iron	geologic mapping	Silver Peak quad	24,000	Siders, M.; Shubat, M.
Juab	geologic mapping	countywide	24,000	Hintze, L.
Juab	geologic mapping; economic mapping	Keg Mountain	24,000	Shubat, M.
Juab, Millard	Quaternary geology	Sevier Desert	24,000	Oviatt, C.G.
Juab, Sanpete, Utah, Sevier	stratigraphy	central Utah		Sprinkel, D.A.
Juab, Millard, Tooele, Utah	CUSMAP Delta mineral occurence database	Delta quadrangle		Hand, J.S.
Kane	geologic mapping	Rainbow Point, Calico Peak, Elephant Butte quads	24,000	Doelling, H.H.
Kane, Emery	economic geology of wilderness areas			Tripp, B.T.; Blackett, R., Brandt, C.J.
Kane, Garfield	coal resource analyses	Alton coal field	24000/ 100,000	Keith, A.; Sommer, S.N.
Millard	Quaternary geology	Whirlwind Valley, Red Knolls area, Ferguson desert	24,000	Davis, F.D.
Millard	stratigraphy, structure	Burbank Hills		Hintze, L.F.
Millard	Quaternary geology	Black Rock Desert		Oviatt, C.G.
Salt Lake	engineering geology	Salt Lake Valley		Case, W.F.

County(ies)	Type of study	Location	Map scale	Geologist/Investigator
Salt Lake	engineering geology	Salt Lake Valley		Lund, W.R.
Salt Lake, Box Elder, Cache, Davis, Utah, Weber	engineering geology	Wasatch Front		Case, W.F.
Salt Lake, Sanpete, Sevier, Utah	structural and stratigraphic cross sections	Wasatch Mountains and Wasatch Plateau	250,000/ 500,000	Kerns, R.
Salt Lake, Box Elder, Davis Tooele, Weber	brine chemistry	Great Salt Lake		Gwynn, J.W.
Sanpete	engineering geology	countywide		Case, W.F.
Sevier	environmental/engineering geology	countywide		Klauk, R.H.
Sevier, Sanpete	geologic mapping	Sigurd, Aurora, Redmond Canyon, Richfield quads	24,000	Willis, G.
Tooele, Box Elder	brine chemistry	Great Salt Lake Desert		Gwynn, J.W.
Tooele, Box Elder	brine chemistry	west pond		Gwynn, J.W.
Utah	petroleum potential	southern Wasatch Front	250,000	Kerns, R.
Wasatch	engineering geology	countywide		Case, W.F.
Washington	re-evaluation of Virgin oil field	west of Zion Park		Brandt, C.J.; and others
northern Utah	economic geology database (MRDS)		24,000	Tripp, B.T.; Mohammed, H.; Shubat, M.; Blackett, R.
statewide	carbon dioxide resources of Utah			Brandt, C.J.
statewide	sample library catalog			Brandt, C.J.; Laine, M.D.
statewide	computerized bibliographies			Burt, C.D.; Hand, J.S.
statewide	petroleum sample database management system			Burt, C.D.; Hand, J.S.
statewide	acid rain			Case, W.F.
statewide	seismic hazards		750,000	Christenson, G.E.
statewide	brine chemistry	oil fields	750,000	Gwynn, J.W.; Brandt, C.J.
statewide	coal chemistry database management system			Hand, J.S.
statewide	coal petrography database management system			Hand, J.S.
statewide	map index database system			Hand, J.S.
statewide	mineral occurrence database system			Hand, J.S.
statewide	petroleum brine database management system			Hand, J.S.
statewide	stratigraphic database management system			Hand, J.S.
statewide	geographic information systems			Hand, J.S.; Burt, C.D.
statewide	radiometric age data base management system			Hand, J.S.; Burt, C.D.
statewide	site investigation database management system			Hand, J.S.; Burt, C.D.
statewide	landslide inventory		100,000 500,000	Harty, K.M.
statewide	lake flooding and dam failure inundation compilation		750,000	Harty, K.M.
statewide	Quaternary fault maps		500,000	Hecker, S.
statewide	shallow ground water		750,000	Hecker, S.
statewide	coal quality analyses of Utah's coal fields			Keith, A.
statewide	National Coal Resource Data System (NCRDS),			Keith, A.; Sommer, S.N.; Hucka, B.
statewide	statistical analysis of petrographic samples from methane coal core			Smith, A.
statewide	coal sample library of Utah coals Univ. of Utah eng. exp. station cooperative			Sommer, S.N.; Smith, A
statewide	zeolites and economic geology			Tripp, B.T.; Mayes, B.
n/a	automated administrative support systems			Burt, C.D.
n/a	computerized library management system			Burt, C.D.; Hand, J.S.
n/a	petrography analysis system			Hand, J.S.
n/a	public access bulletin board system			Hand, J.S.; Burt, C.D.
n/a	research and development of geological modelling systems			Hand, J.S.; Burt, C.D.
n/a	research and development of knowledge-based interfaces			Hand, J.S.; Burt, C.D.
n/a	geological hazards database management system			Hand, J.S.; King, A.
n/a	Great Salt Lake chemistry database management system			Sturm, P.S.; Hand, J.S.

N·E·W P·U·B·L·I·C·A·T·I·O·N·S

Open-File Reports

Open-File Report 105, *Geologic map of Porcupine Reservoir quadrangle, Cache Co., Utah,* by Lea Berry (review copy).

Open-File Report 106, *Quaternary geology of part of the Sevier Desert, Millard Co., Utah,* by Charles G. Oviatt (review copy).

Open-File Report 107, *Ground water resources of the southern Wasatch Front,* by Don Price and L.S. Conray (review copy).

Open-File Report 108, *Potential radon hazard map of Utah,* by Douglas A. Sprinkel. Map of Utah, scale 1:100,000, showing potential radon areas and sources; a 3-page text is included.

Open-File Report 109, *Utah's geologic hazards: a review for realtors* by G.E. Christenson and D.R. Mabey. This 7 page introduction to hazards and information for realtors-in-training also serves as a good layman's preface to destruction prevention from Utah's varied hazards.

Open-File Report 110, *Geologic map of Roger Peak quadrangle, Garfield Co., Utah,* by Weir, Williams and Beard (review copy).

Open-File Report 111, *Geologic map of Escalante quadrangle, Garfield Co., Utah,* by Williams, Weir and Beard (review copy).

Bulletins

Water Resources Bulletin 25, *Effects of breaching the Southern Pacific Railroad causeway, Great Salt Lake, Utah - physical and chemical changes August, 1984 to July, 1986,* by J.W. Gwynn and P.A. Sturm. A 25-page summary studies conducted by the UGMS and USGS to determine the changes resulting from breaching the causeway which divides the Great Salt Lake.

Miscellaneous Publications

Miscellaneous Publication 87-1, *Rockhound guide to selected rock and mineral localities in Utah,* by Martha R. Smith. An introduction for people interested in collecting in Utah.

Miscellaneous Publication 87-6, *Semiprecious gemstones and ornamental stones found in Utah,* adapted by Martha R. Smith. An introductory guide to Utah's gemstone treasures with sources and information.

A reissue of an old favorite: *Earthquake Studies in Utah, 1850 to 1978,* edited by Walter J. Arabasz, Robert B. Smith and William D. Richins, 1979, 552 pages, spiral bound; this is the catalog of the University of Utah Seismograph Stations as well as several earthquake-related papers.

CRASS CLAST CRASHES CLAMBAKE!

A barbeque party was rudely interrupted when a boulder two feet in diameter made a social comment by landing on the grill. The incident occurred the evening of 5 July, 1987, in the backyard of a house in the high avenues of Salt Lake City on North Cliff Drive. The rockfall clast originated from a back yard on North View Drive which is perched on a sand and gravel slope deposited by Ice-Age Lake Bonneville when it was at the Bonneville Level (5090 feet).

Craig V. Nelson, Salt Lake County Geologist, reported that the county was first notified when the owner of the barbeque grill asked about possible legal retribution. Craig, and Salt Lake City Environmental Planner Robert H. Buchanan, visited the scene of the crime on the 10th of July but missed seeing the culprit rock, presumably because it was retrieved by its previous owner.

Other boulders, partially hidden in weeds, appeared to be ready to follow their sibling and crash a party of their own. Slopes in the area were oversteepened when toes were removed during home construction. Erosion of the slope is gradually exposing large boulders which eventually must live down to their potential energy. Craig recommended a taller railroad tie retaining wall to prevent other social interruptions.

Interesting legal precedents, albeit small scale, may be set by the incident. Should the upslope owner be responsible for "acts of God" and replace the barbeque grill? Who owned the recalcitrant intruder, the source person or the receivership plaintiff?

There are copious boulders on retreating, oversteepened, slopes in the neighborhood to cause a recurrence of the problem.

UGMS Staff Changes...

Staff changes since last issue include:

Charles Bishop, part-time with the Minerals group is now a full-time geotech in the Mapping Section. *Bill Black,* geotech receptionist will move to the Site Investigations Section while two new employees, *Antonia (Tandy) Hedrick and Christine Wilkerson* will share the receptionist position.

Martha Smith has retired after 10 years of service to the UGMS as Editor (3½ years) and Information Specialist (6½ years). Martha has her degree in Geology from Pomona College, California and was a U of U Ph.D. candidate. She is spending her time painting, writing, gardening......*sigh*. Good Luck, Martha.

Announcements...

Publishing company specializing in non-fiction earth science/geology books for young people seeks writers who can simplify complex geology concepts. Authors must be interested in writing for young readers. Please send query letter to: Mark Enslow, Enslow Publishers, Box 777, Hillside, NJ 07205.

The Society of Mining Engineers International Meeting *Gold Exploration: Techniques, Concepts, and Problems* will be held on October 13-15, 1988 in Reno, Nevada.

The Annual Investor's Review of New North American Gold Projects: 1987, recently published by the Metals Econonics Group, is the new companion piece to their The Annual Investor's Review.

EARTHQUAKE SCIENTIST

The Utah Geological and Mineral Survey has an opening for a senior Earthquake Scientist. Successful candidate will contribute toward the operation and growth of the earthquake program in Utah. A minimum of 60% of time will be directed toward implementing and coordinating joint federal/state earthquake programs encouraging the adoption of loss-reduction measures associated with earthquakes in Utah. Remaining time can be used to pursue research interest in earthquake-related studies. Applicants interested in less than full time employment will also be considered.

Position requires Bachelors degree in geology, geophysics, or engineering geology plus six (6) years of professional related employment, or an equivalent combination of education and experience.

Excellent benefit package with annual salary of $29,462 to $36,227. If qualified, submit resume including transcripts by October 30, 1987 to:

Utah Department of Natural Resources
Attention Human Resource Management
1636 West North Temple,
Salt Lake City, Utah 84116
Equal Opportunity Employer

UTAH NATURAL RESOURCES
Utah Geological and Mineral Survey
606 Black Hawk Way
Salt Lake City Utah 84108-1280

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